the Journal of CONTEMPORARY DENTAL PRACTICE at www.thejcdp.com
Volume 5 Number 4 November 15, 2004 Fall Issue

Evaluation of the Diagnostic Advantage of Intraoral D and E Film for Detecting Interproximal Caries

Fatemeh Ezoddini Ardakani, DDS, MS; Abdolrahim Davari, DMD, MS
Daryoush Goodarzipour, DDS, MS; Koorosh Goodarzipour, DDS

Abstract

Clinicians strive to reduce the exposure of patients to X-ray radiation in an effort to decrease its harmful effects on the body. A potential strategy for achieving this goal is the use of high-speed films that require less exposure to radiation to generate a diagnostic image. There are two film types commonly used in intraoral radiography: high speed or "Ekta-speed" film (Type E) and normal speed or Ultra-speed film (Type D). Type E film requires nearly half of the exposure time that is required by Type D films to produce an acceptable diagnostic image; however, the diagnosis quality and usability of these film types are under question.

The purpose of this research is to compare the diagnostic quality of Type E with Type D film when used to diagnose proximal caries. In this study 40 pairs of extracted maxillary premolar teeth were chosen and divided into four groups of 10 pairs. Cavities were made on proximal surfaces at different depths (0.5, 1, 1.5, and 2 mm) for each group. Bitewing radiographs were then taken on each pair of teeth using Type E film and then again using Type D film. Radiographs were evaluated by two oral radiologists and two operative dentistry specialists who recorded the perceived diagnostic depth of the prepared cavities.

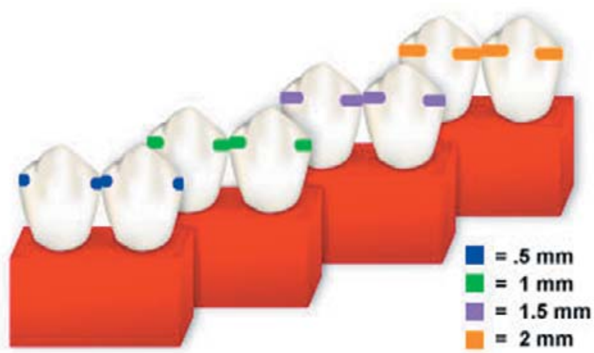
Our data showed both Type D and E films are suitable for use in diagnosing proximal caries, and despite a minor discrepancy between them no significant difference was found with regard to their value in diagnosing proximal caries.

Keywords: Proximal caries, Intraoral D film, Intraoral E film, radiography

Citation: Ardakani FE, Davari A, Goodarzipour D, et. al. Evaluation of the Diagnostic Advantage of Intraoral D and E Film for Detecting Interproximal Caries. J Contemp Dent Pract 2004 November;(5)4:058-070.

Introduction

The use of dental radiographs is one of the most important diagnostic techniques used in diagnosing oral diseases and defects, however, the harmful effects of X-radiation on biologic systems are well known. This well known fact causes clinicians to strive to minimize the exposure of patients, while attempting to obtain the most favorable X-ray image for diagnostic use.[1] In recent years the use of faster or more sensitive Type E film instead of the slower Type D film is recommended to decrease the exposure of patients to X-radiation.[1] Type D film requires a relatively long exposure time and results in a quality image. On the other hand Type E film requires a shorter exposure time, but the sharpness and resolution of the resulting image compared to Type D film may be questionable.



Dental caries is one of the most common chronic diseases in the world.[1,2] Due to their inaccessibility proximal contact areas are the second highest disposed areas for caries following caries in pit and fissure areas.[2] They are almost always obstructed physically, which minimizes the self-cleansing associated with the ingestion of non-adherent foods and adequate salivary flow. The number and types of organisms that are found in proximal surface plaque varies.[2] Early stage incipient caries are limited to a demineralized surface without a cavity and can be treated with fluoride and antimicrobial treatment, while a carious lesion that reaches the cavitation stage is usually treated using restorative techniques.[2]

Clinical examination and radiography are the most common methods used in the diagnosis of proximal surface caries. Clinical methods of diagnosing proximal caries are difficult due to the inaccessible location of these lesions. The percentage of accuracy and sensitivity of clinical examination in investigating proximal caries is only 30% and indicates the need for reliance on radiographic interpretation.[3] Radiographic image of caries on the proximal surface is dependent on the loss of enough mineralized tissue to show detectable changes in radiographic density. Since proximal surfaces of posterior teeth are often wide buccolingually, minor losses of mineralized tissue in incipient lesions, or in the progression of large existing lesions, are difficult to recognize on radiographs. This makes the diagnosis of the depth of caries on a radiograph actually less than the true depth of the lesion in the tooth. At least 40% of dental tissue is required to be demineralized before caries can be detected on a radiograph.[1]

Diagnosing the size of caries using radiography is very important. Since restorative treatment is usually based on X-ray findings, it is essential that radiographic images are as accurate as possible. The inability to diagnose caries on a radiograph can result in unnecessary destruction of tooth tissue.[4]

Factors in the creation of a suitable radiographic image to detect proximal caries are the angle of the X-ray beam passing through the subject, exposure time, and the speed of the film used. Divergence from the best horizontal angle decreases the sensitivity of film, while an excessive vertical angle causes loss of specificity of film.[5] Radiographic film speed is based on the quantity of radiation required to create an image with standard density. In other words a high speed film needs less exposure to radiation for image formation, while a low speed film needs more exposure to radiation to create image with the same density when film processing factors are identical. For example, to create an image of similar density Type F film requires half the exposure time than Type E film i.e., the speed of Type F film will be twice the speed of Type E film. The fastest film available for use in dentistry today is Type E film. Only films with D or E speed ratings are suitable for intraoral radiography. Most of the film used in the United States is Kodak D and E films.[1]

In 1999 the accuracy of the images from Type E film, digital images of desktop-monitors, and laptop computers were compared for use in diagnosing dental caries. There was no significant difference among these three viewing methods.[6] Sanderink et al.[7] compared radiographic films with digital radiographic systems for investigating caries. They found the diagnostic accuracy of digital systems is comparable to radiographic films, but the major factor in radiographic diagnosis is the dentist's ability in diagnosing caries, not the radiographic method use. Blendlc et al.[8] compared intraoral films at different speeds with intraoral digital radiography. They found digital radiography requires half of the exposure time required by the fastest intraoral films to create an acceptable diagnostic image.

Proper film processing can influence the quality of a radiographic image and its value in the detection of small defects in hard and soft tissues. Film developing using a higher temperature can, in effect, increase the film speed, but it will result in a reduction of film sharpness. Correct technique in film processing can reduce the necessary radiation dose. Farman and Farman[9] compared the accuracy of Type F film with D and E film and the effect of different film processing solutions on different films. They found no difference in the diagnostic quality of Type E and F films. In addition they found different developer solutions can change the quality of radiographic images.[9]

The value of a high quality radiographic image is an invaluable asset to the dentist in the diagnosis of orofacial disease. Unfortunately more exposure of the patient to X-radiation has been required in the past due to the use of slower speed film. The aim of this research was to investigate the diagnostic quality of faster Type E films with slower Type D films in terms of image accuracy in the diagnosis of proximal caries and the radiation exposure of the patient.

Materials and Methods

Eighty extracted maxillary premolar teeth without fractures nor caries in the anatomic crown area were selected for this study. Using a 1 mm diameter carbide fissure bur, simulated class II cavities were prepared in a proximal surface of some of these teeth. The teeth were approximated in pairs by embedding them in soft red wax to simulate the natural position of teeth in the mandibular arch. The wax covered the entire length of the teeth from the root to the anatomic crown area in order to prevent movement. The embedded teeth were divided into 4 groups of ten pairs each. Cavities of 0.5, 1, 1.5, and 2 mm depths were prepared in proximal surfaces of the teeth in each group. Each pair of teeth had four proximal cavities with the same depth resulting in every group of ten pairs with all depths represented. These cavity depths were prepared in the same manner in all proximal surfaces of every pair.

Each pair of teeth was radiographed once using Type D film then again using Type E film. The embedded teeth were placed on radiographic film, and the cone of the X-ray head was oriented to create a vertical angle perpendicular to the long axis of the dental crowns to maximize the visibility of the proximal surface of the teeth in the resultant image. (Figure 1)

Figure 1. Method of preparing radiographs.

The teeth were put on radiographic film in the direction of the film length. The cone of the x-ray head was put at a vertical angle to the linear axis of the crowns in order to make the proximal surface of the teeth clear in the radiograph.

All radiographic images were prepared using a Planmeca X-ray machine, with a standardized exposure time of 0.16 s, at 60kv and 8mA settings. Kodak Type D and E films were used. The same film processing criteria (6 minutes) was used for all films. After drying the films, a number or a code was engraved on each film (Figure 2).

Figure 2. Film numbers were engraved on the film to realize the type of film. True depth and diagnostic depth was recorded.

Figure 3. The Negatoscope used by observers.

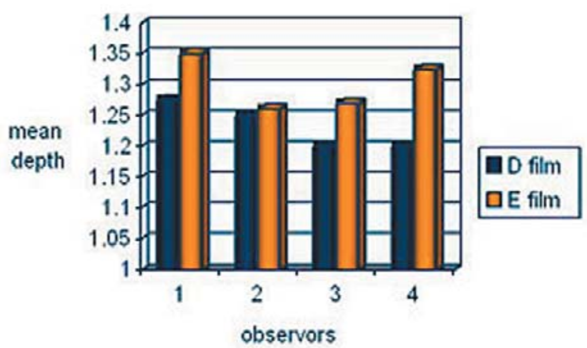


Figure 4. Diagram showing the mean of diagnostic depth detected by four different observers.

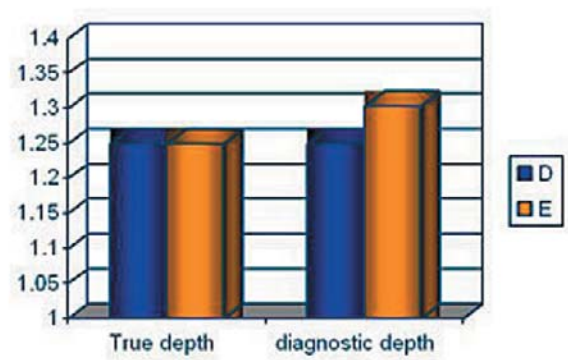


Figure 5. Diagram showing differences between the mean of diagnostic depth (detected by four different observers) and the mean of true depth.

Then all of these 80 films were analyzed by two oral radiologists and two operative dentistry specialists using the same negatoscope set (Figure 3).

The examiners measured the cavity depth from mesial to distal using a probe with 0.5 mm scales. In each radiograph four cavities with the same depth were examined and the measurements were recorded in a table. Each table was designed with 80 rows. Each row was dedicated to one film, while the column headings contained the film number there were different columns for 0.5, 1, 1.5, and 2 mm cavities. The diagnostic depth was marked in the related columns. Each of the four examiners completed a personal table for all radiographs. The examiners' four tables plus a table with the true depths were analyzed statistically. The diagnostic quality of Type D and E films were compared using this analysis (Table 1).

Input variables were categorized and analyzed using SPSS software (Figures 4 and 5).

Table 1. An abbreviated example of a data table layout.

Number of film	True depth (mm)	Observer 1 (mm)	Observer 2 (mm)	Observer 3 (mm)	Observer 4 (mm)	Type of film (D,E)
1	.50	.50	.50	.50	.50	1
2	.50	.50	.50	.50	.50	1
11	.50	.50	.50	.50	.50	2
12	.50	.50	.50	1.00	.50	2
21	1.00	1.00	1.00	1.00	2.00	1
22	1.00	1.00	1.00	.50	1.00	1
31	1.00	1.00	1.00	1.00	1.00	2
32	1.00	1.00	1.00	1.00	1.00	2
41	1.50	2.00	1.50	1.50	1.50	1
42	1.50	2.00	1.50	1.50	1.50	1
51	1.50	1.50	1.50	1.50	1.50	2
52	1.50	1.50	1.00	1.50	2.00	2
61	2.00	2.00	2.00	2.00	2.00	1
62	2.00	2.00	2.00	2.00	2.00	1
71	2.00	2.00	2.00	2.00	2.00	2
72	2.00	2.00	2.00	2.00	2.00	2

Table 2. Analysis of variance for evaluating the efficacy of regression model.
This table shows the linear relation between diagnostic depth and true depth which is due to the significance of p- value as it relates to Type E films.

Model	Sum of squares	df	Mean of squares	F	p-value
1 Regression	11.796	7	11.796	637.000	0.0001
Residual	0.704	38	1.825E- 20		
Total	12.5	39			

Note:

Sum of squares regression is related to the value of regression variance.

df = degrees of freedom

F = Fisher test done for significance of regression line

Regression analysis was done separately for Type E and D film. Regression analysis was done for obtaining true depth from diagnostic depth. In this method we find a linear equation ($y = a + bx$) between true depth (dependent variable “y”) and diagnostic depth (independent variable “x”). The constant value is “a” and the line slope is “b.”

Results

Results relating to Type E film are shown in Tables 2 and 3. In this analysis the dependent variable is true depth and independent variableis diagnostic depth. Regression analysis and the achieved results related to Type E film, standard deviation, sum of squares, and average squares are shown in Table 2. In this table p-value is 0.0001. The regression analysis was used for evaluation of the true depth from diagnostic depth. The regression coefficient and true depth are shown in Table 3. The relationship between true depth and diagnostic depth are shown in this table and are evaluated as follows:

True depth = (diagnostic depth x 1.037) - 0.0463.

Results relating to Type D film are shown in Tables 4 and 5. Regression analysis and the achieved results related to D film, sum of

Table 3. This table shows the relationship between true and diagnostic depth according to a linear relationship pertaining to relate to Type E films.

Using this table the true depth by diagnostic depth can be assessed using the following formula:
True depth = -0.0463 + (diagnostic depth x 1.037)

Model	Unstandardized Coefficients	t	p-value
1 (Constant)	-4.630E-02	-0.0831	0.411
Diagnostic Depth	1.0937	25.239	0.0010

Note:

Unstandardized coefficients is related to the regression line (y = a + bx). The constant value is "a", the line slope is "b", true depth is "y" and diagnostic depth is "x".

t = t-test analysis

Table 4. This table shows linear relation between diagnostic depth and true depth related to Type D films which is due to the significance of p-value.

Model	Sum of squares	df	Mean of squares	F	p-value
1 Regression	12.023	7	12.023	957.368	0.0001
Residual	0.477	38	1.256E-02		
Total	12.500	39			

Note:

df = degrees of freedom

F = Fisher test

Table 5. This table shows the relationship between true and diagnostic depth related to D films according to linear relation.

According to this table the true depth can be assessed by diagnostic depth:
True depth= -0.17 (diagnostic depth x 1.09)

Model	Unstandardized Coefficients	t	p-value
1(constant)	-0.170	-3.460	0.001
Diagnostic Depth	1.090	30.941	0.000

Note:

Unstandardized coefficients is related to the regression line (y = a + bx). The constant value is "a", the line slope is "b", true depth is "y" and diagnostic depth is "x".

t = t-test analysis

Table 6. Comparing the percentage of errors (difference between true and diagnostic depth) in both films by T- Test.

Type Of film	The average of difference between true and diagnostic depth (error)	Standard Deviation
D	0	0.135
E	0.531	0.1197

p-value = 0.06

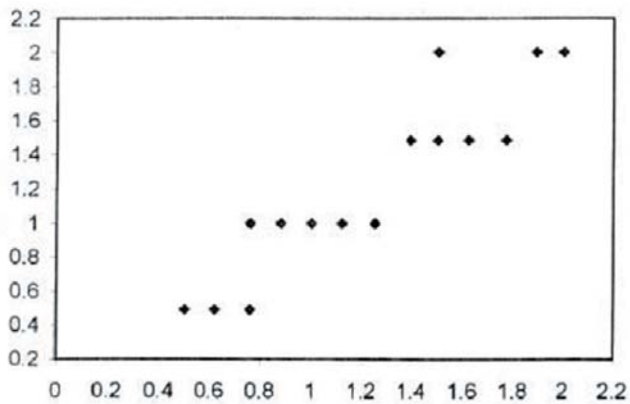


Figure 6. Relationship between true and diagnostic depth on Type E film.

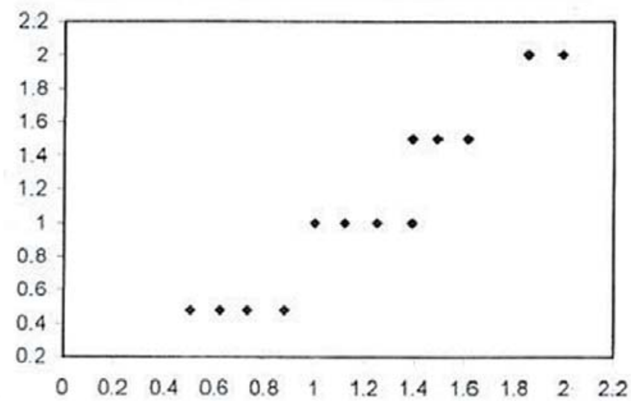


Figure 7. Relationship between true and diagnostic depth on Type D film.

squares, average squares, and related coefficients are shown in Table 4. The p-value is 0.0001. Regression coefficients and standard deviation for diagnostic depth are shown in Table 5. The relationship between true depth and diagnostic depth are shown in this table are evaluated as follows:

True depth = (diagnostic depth x 1.09) - 0.17.

After these analyses, the achieved results from both groups were evaluated by T-test and are shown in Table 6. Type D film is compared with Type E film regarding the percentage of error in diagnosing cavity depth. In this table p-value is 0.06 and T is 1.85. The relationship between true depth and diagnostic depth in Type E film is shown in Figure 6, while this relationship for Type D film is shown in Figure 7.

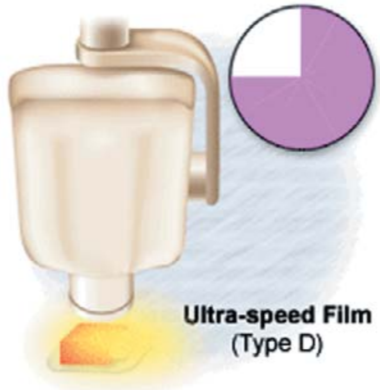
Discussion

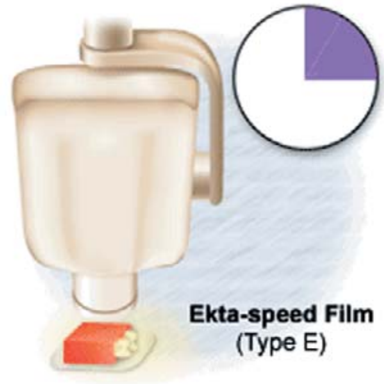
At the present time, X-radiation is used for diagnostic and treatment purposes in oral healthcare. In order to minimize harmful effects of radiation on the body, care must be taken to decrease the radiation dose as much as possible.

Our data showed there is not a significant difference between true depth and diagnostic depth of proximal carries in Type D film. In other words, in Type D film there were no differences between the true depth and diagnostic depth defined by observers. In addition, the differences between true depth and diagnostic depths in similar depths are more apparent (between depths 0.5 and 1.0 mm or depths 1.5 and 2.0 mm); therefore, Type D film has a good sensitivity for diagnosing caries.

Our data analyzing and related tests about Type E films showed there is a significant difference between true depth and diagnostic depth. This difference is small, but it is affected by two factors. First the human factor is unique to the observers in terms of their visual acuity and diagnostic accuracy. The second factor is the limited numbers of samples (n=80). Using more samples would increase the accuracy of the research and decrease the error rate. Considering these factors and the benefit of less radiation used for exposing Type E film (about half of that in Type D film), the small statistical difference between true depth and diagnostic depth in Type E film can be ignored. In practical terms, we can say Type E films do differ in a meaningful way from Type D films with regard to their diagnostic value in diagnosing proximal dental caries.

Hurlbart and Wuehrmann[10] compared standard intraoral films with panoramic films in diagnosing proximal caries. Their results show that for diagnosing caries which extend into the enamel and penetrate into the dentin, all standard films except panoramic films are usable and useful. While for diagnosing caries which penetrate from enamel and developed about half or more than half from the dentinoenamel junction to pulp, there is no significant difference in using panoramic film and intraoral films.[10] They concluded caries with less depth need more accuracy and are more difficult to diagnose. Similarly, in our study there was a difference between the diagnostic ability of Type D and E films in diagnosing the low depth caries





(0.5 and 1.0 mm). In the previously mentioned studies there was not a significant difference between Type D and E films regarding their ability in diagnosing proximal caries. Certainly these results depend on the number of samples, accuracy of observations, methodology, and the type of research.

There are several studies that show the same results as our study.[11-13] Hintze et al.[11] compared Type E films with D films and digital radiography for diagnosing proximal enamel caries and occlusal dentin caries. In total, 122 proximal enamel caries were investigated by three observers, and 56 occlusal dentine caries were investigated by two observers. They showed there was not a significant difference between these radiographs in diagnosing the caries.[11] Kleier et al.[12] compared Type D films with E films in revealing interproximal caries. Radiography was taken from molars and premolars using machine settings of 60, 70, or 90 KVP and 75 mA. Radiographs were analyzed by ten dentists to investigate the extent of dental caries. The achieved result showed that statistically there was no considerable difference between Type E and D film in diagnosing caries.[12] In a study conducted by by Ashton and Waggoner[13], Kodak D films were compared to E films for diagnosing proximal caries. There was no significant difference in a dentist's ability in diagnosing caries, using Type D films compare to Type E films. These results are similar to ours.[13]

Sanderink et al.[7] compared radiographic films with digital radiographs for investigating caries. The surface in 56 extracted teeth was investigated under standardized conditions by using Type E film and digital radiography. Images were investigated by four radiologists and four dentists. Their data showed that diagnostic accuracy of digital systems could be compared to radiographic films. The methodology of this study is similar to our study.

Farman and Farman[9] compared the quality of Type F films with Type D and E films. They also tested the effect of different solutions on film processing. Their study shows the quality of Type F film images is similar to Type E film, and the kind of chemical solution used does have an effect on the quality of images.

The present study is more accurate compared to similar studies because most previous studies used teeth with existing proximal caries. Actual carious lesions have a gradual decalcification of enamel and dentin and lack a specific lesion margin as was the case in the present study. It seems carious teeth are not favorable specimens for comparing the sensitivity of type D and E film. The present study used controlled fabricated cavities with distinct margins on the proximal surface of extracted teeth.

Conclusion

Overall, Type E films do not significantly differ from with type D films regarding their value in diagnosing proximal caries. The small error which is seen in the diagnostic value of type E films considering the reduction of radiation absorbing dose could be ignored. Our results are similar to the results of other studies. It can be suggested E films should be used for intraoral radiographs taken to detect proximal caries in order to protect patients from harmful effects of radiation on biological systems in routine treatment of dentistry.

References

1. White C, Pharoah, J. Oral radiology principles and interpretation. Fourth edition, 2000, Mosby , Missouri , USA .
2. Roberson TM, Heymann HO, Swift EJ. Art and Science of Operative Dentistry, 4 th ed. 2002, Mosby , Missouri , USA .
3. Heinrich R, Kunzel W, Tawfiq H. [Ther diagnosis of approximal caries--a comparison of clinical, fiber optic and x-ray diagnostic procedures (the diagnosis of approximal caries)] Dtsch Zahn Mund Kieferheilkd Zentralbl. 1991;79(7):535-42. German.
4. Grondahl HG. Radiographic caries diagnosis. A study of caries progression and observer performance. Swed Dent J Suppl. 1979(3):1-32.
5. van der Stelt PF, Ruttiman UE, Webber RL, et. al. In vitro study into the influence of X-ray beam angulation on the detection of artificial caries defects on bitewing radiographs. Caries Res. 1989;23(5):334-41.
6. Ludlow JB, Abreu M Jr. Performance of film, desktop monitor and laptop displays in caries detection. Dentomaxillofac Radiol. 1999 Jan;28(1):26-30.
7. Syriopoulos K, Sanderink GC, Velders XL, et. al. Radiographic detection of approximal caries: a comparison of dental films and digital imaging systems. Dentomaxillofac Radiol. 2000 Sep;29(5): 312-8.
8. Blendl C, Stengel C, Zdunczyk S. [A comparative study of analog and digital intraoral x-ray image detector systems] Rofo. 2000 Jun;172(6):534-41. German.
9. Farman TT, Farman AG. Evaluation of a new F speed dental X-ray film. The effect of processing solutions and a comparison with D and E speed films. Dentomaxillofac Radiol. 2000 Jan;29(1):41-5.Erratum in: Dentomaxillofac Radiol 2000 Mar;20(2):131.
10. Hurlburt CE, Wuehrmann AH. Comparison of interproximal carious lesion detection in panoramic and standard intraoral radiography. J Am Dent Assoc. 1976 Dec;93(6):1154-8.
11. Hintze H, Wenzel A, Jones C. In vitro comparison of D- and E-speed film radiography, RVG, and visualix digital radiography for the detection of enamel approximal and dentinal occlusal caries lesions. Caries Res. 1994;28(5):363-7.
12. Kleier DJ, Hicks MJ, Flaitz CM. A comparison of Ultraspeed and Ektaspeed dental x-ray film: in vitro study of the radiographic appearance of interproximal lesions. Oral Surg Oral Med Oral Pathol. 1987 Mar;63(3):381-5.
13. Waggoner WF, Ashton JJ. Comparison of Kodak D-speed and E-speed x-ray film in detection of proximal caries. ASDC J Dent Child. 1988 Nov-Dec;55(6):459-62.

About the Authors

Fatemeh Ezoddini Ardakani, DDS, MS

Dr. Ardakani is an Assistant Professor and serves as the Chair of the Department of Oral and Maxillofacial Radiology and a research deputy in the Faculty Dentistry at the Shahid Sadoughi Medical University in Yazd, Iran. She has authored several papers and is a recognized international speaker on the subject of oral and maxillofacial radiology.

e-mail: afsan40@yahoo.co.uk

Abdolrahim Davari, DMD, MS

Dr. Davari is an Assistant Professor in the Department of Operative of the Faculty of Dentistry at Shahid Sadoughi Medical University in Yazd, Iran.

Daryoush Goodarzipour, DDS, MS

Dr. Goodarzipoor is an Assistant Professor in the Department Oral and Maxillofacial Radiology of the Faculty of Dentistry at Tehran University in Tehran, Iran. He lectures frequently at international dental conferences and has published several articles in Iranian dental journals on the subject of oral and maxillofacial radiology.

Koorosh Goodarzipour, DDS

Dr. Goodarzipoor graduated from the Faculty of Dentistry at Shahid Sadoughi Medical University in Yazd, Iran in 2003. He is now in private practice.

Hossein Fallahzadeh, PhD

Dr. Fallahzadeh is a biostatistician in the Faculty of Health Science at Shahid Sadoughi Medical University in Yazd, Iran.